

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Yuji Judai : Art Unit:  
 Serial No.: To Be Assigned : Examiner:  
 Filed: Herewith :  
 FOR: SEMICONDUCTOR DEVICE AND :  
 ITS FABRICATION METHOD :

DIVISIONAL OF:

Applicant: Yuji Judai : Art Unit: 2814  
 Serial No.: 09/177,038 : Examiner: H. Weiss  
 Filed: October 22, 1998 :  
 FOR: SEMICONDUCTOR DEVICE :  
 HAVING A FERROELECTRIC :  
 CAPACITOR WITH TENSILE STRESS  
 PROPERTIES

**PRELIMINARY AMENDMENT**

Assistant Commissioner for Patents  
 Washington, D.C. 20231

S I R :

Prior to examination, please amend the above-identified  
 application as follows:

IN THE TITLE:

Please delete the title in its entirety and substitute therefore:

099044-13404

SEMICONDUCTOR DEVICE HAVING A  
FERROELECTRIC CAPACITOR WITH TENSILE STRESS  
PROPERTIES

IN THE DRAWINGS:

Subject to approval by the Examiner in charge of the above-identified application please enter the corrections to Figs. 3 and 4 as shown on the accompanying red-inked sketched. Specifically, Figs. 3 and 4 have been designed with the legend "Prior Art".

IN THE SPECIFICATION:

Specification at page 1, line 3:

This application is a division of U.S. Patent Application No. 09/177,038 filed October 22, 1998.

Specification at page 3, line 16:

SUMMARY OF THE INVENTION

The present invention is made to solve the above conventional problems and its object is to provide a semiconductor device capable of integrating a ferroelectric thin film free from characteristic deterioration and its fabrication method.

A semiconductor device of the present invention comprises a circuit board, a ferroelectric capacitor arrange on the circuit board having a ferroelectric think film and top and bottom electrodes which are formed so as to hold said ferroelectric thin film, an insulating film formed on the circuit board so as to cover said ferroelectric capacitor, a metallic wiring film formed on the insulating film so as to connect with either of the top and bottom electrodes, and a surface protective film formed so as to cover the

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insulating film and the metallic wiring film, wherein a synthetic stress working in a surface direction of the ferroelectric thin film of said ferroelectric capacitor is an extensional stress.

In another aspect of the present invention, the insulating film, metallic wiring film, and surface protective film provide the surface-directional extensional stress of the ferroelectric thin film of the ferroelectric capacitor.

In a further aspect of the present invention, the metallic wiring film is constituted with two layers which are different kinds of metal.

A semiconductor device fabrication method for fabricating the semiconductor device of the present invention comprises the step of: forming said insulating film on said ferroelectric capacitor by the TEOS-CVD method utilizing TEOS activated by  $O_3$ .

A semiconductor device fabrication method for fabricating the semiconductor device of a further aspect of the present invention is such that the metallic wiring film is constituted with two layers where a bottom layer thereof is made of TiN, and such step of heat-treating of said formed TiN layer in a temperature range of 200 to 650°C after forming said TiN layer is included.

A semiconductor device fabrication method for fabricating the semiconductor device of another aspect of the present invention is such that said metallic wiring film is constituted with two layers where a top layer thereof is made of Al, and such step of forming said Al layer through the sputtering method while heating said circuit board in a temperature range of 100 to 400°C is included.

A semiconductor device fabrication method for fabricating the semiconductor device of a still further aspect of the present invention is such that said surface protective film is made of SiN, and such step of forming

said surface protective film by depositing SiN through the plasma-excitation CVD method having an RF power of 300 W or less is included.

The above semiconductor device of the present invention can show a superior performance that the ferroelectric-pair thin film of the ferroelectric capacitor is not deteriorated.

Moreover, the semiconductor device fabrication method of the present invention can realize a semiconductor device having the above superior performance.

Specification at page 7, line 6:

The semiconductor device of this embodiment is characterized in that the sum of stresses of thin films deposited on the ferroelectric capacitor is an extensional stress. In FIG. 1, arrows show stress directions of thin films. Because the sum of stresses of thin films formed on the ferroelectric capacitor has an extensional direction, an extensional stress or tensile is applied to the ferroelectric capacitor to prevent ferroelectric characteristics from deteriorating.

Specification at page 7, line 15:

Moreover, the semiconductor device of this embodiment is characterized in that every thin film deposited on the ferroelectric capacitor applies an extension-directional stress to the ferroelectric capacitor. Because every thin film deposited on the ferroelectric capacitor has an extension-directional stress, an extensional or tensile (hereinafter "extensional") stress is applied to the ferroelectric capacitor to prevent ferroelectric characteristic from deteriorating.

IN THE CLAIMS:

Please cancel claims 1-4, 6, 7, 10, 13 and 15 and add new claims 16 and 17. Please amend claims 5, 8, 9, 11, 12 and 14 as follows:

5. (Amended) The method for forming a semiconductor device according to claim 16, in which said step f1) includes:

depositing said second insulating film using a TEOS-CVD method utilizing TEOS activated by O<sub>3</sub>.

8. (Amended) The method for forming a semiconductor device according to claim 16, in which said step f2) includes forming a metal

wiring film by: a) depositing a TiN layer, and b) depositing an upper layer.

9. (Amended) The method for forming a semiconductor device according to claim 8, in which said step of forming a metal wiring film further includes heat-treating said TiN layer in a temperature range of 200 to 650°C after forming said TiN layer.

11. (Amended) The method for forming a semiconductor device according to claim 16, in which said step f2) includes forming a metal

wiring film by: a) depositing a base layer, and b) depositing an Al layer.

12. (Amended) The method for forming a semiconductor device according to claim 11, wherein

said step of depositing an Al layer comprises sputtering while heating said circuit board in a temperature range of 100 to 400°C.

14. (Amended) The method for forming a semiconductor device according to claim 16, wherein

said step of forming said surface protective film comprises depositing SiN through a plasma-excitation CVD method having an RF power of 300 W or less.

Please add new claim 16.

16. (Newly Added) A method for forming a semiconductor device, comprising the steps of:

- a) providing a circuit board;
- b) forming a first insulating film at least indirectly on said circuit board;
- c) forming a lower electrode on said first insulating film;
- d) forming a ferroelectric film over said lower electrode;
- e) forming an upper electrode over said ferroelectric film, said lower electrode, ferroelectric film, and upper electrode combining to form a ferroelectric capacitor;
- f) creating a synthetic tensile stress upon said ferroelectric capacitor by:

f1) forming a second insulating film over said ferroelectric capacitor;

f2) forming a metal wiring pattern over said second insulating film; and

f3) forming a surface protective film over said second insulating film and said metal wiring pattern.

Please add new claim 17:

17. (Newly Added) The method as in claim 16, in which step f1) includes forming a plurality of contact openings through said second insulating film for contacting said upper electrode and said lower electrode and step f2) includes providing contact between said metal wiring pattern and said upper and lower electrodes through said plurality of contact openings.

Respectfully Submitted,

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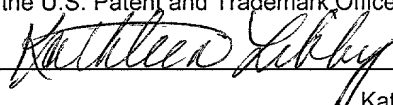
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Kathleen Libby

4240650

## VERSION WITH MARKINGS TO SHOW CHANGES MADE

SPECIFICATION:

Specification at page 1, line 3:

This application is a division of U.S. Patent Application No. 09/177,038 filed October 22, 1998.

Specification at page 3, line 16:

SUMMARY OF THE INVENTION

~~The present invention is made to solve the above conventional problems and its object is to provide a semiconductor device capable of integrating a ferroelectric thin film free from characteristic deterioration and its fabrication method.~~

~~A semiconductor device of the present invention comprises~~

~~a circuit board,~~

~~a ferroelectric capacitor arranged on said circuit board, having a ferroelectric thin film and top and bottom electrodes which are formed so as to hold said ferroelectric thin film,~~

~~an insulating film formed on said circuit board so as to cover said ferroelectric capacitor,~~

~~a metallic wiring film formed on said insulating film so as to connect with either of said top and bottom electrodes, and~~

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~~a surface protective film formed so as to cover said insulating film and said metallic wiring film, wherein~~

~~a synthetic stress working in a surface direction of the ferroelectric thin film of said ferroelectric capacitor is an extensional stress.~~

~~The semiconductor device according to claim 1 of the present invention, is such that~~

~~said insulating film, metallic wiring film, and surface protective film provide the surface directional extensional stress of the ferroelectric thin film of said ferroelectric capacitor.~~

~~The semiconductor device according to claim 1 or 2 of the present invention is such that~~

~~Said metallic wiring film is constituted with two layers which are different kinds of metal.~~

~~A semiconductor device fabrication method for fabricating the semiconductor device of the present invention comprises the step of:~~

~~forming said insulating film on said ferroelectric capacitor by the TEOS CVD method utilizing TEOS activated by O<sub>3</sub>.~~

~~A semiconductor device fabrication method for fabricating the semiconductor device of the present invention is such that~~

~~said metallic wiring film is constituted with two layers where a bottom layer thereof is made of TiN, and~~

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~~such step of heat treating of said formed TiN layer in a temperature range of 200 to 650°C after forming said TiN layer is included.~~

~~A semiconductor device fabrication method for fabricating the semiconductor device of the present invention is such that~~

~~said metallic wiring film is constituted with two layers where a top layer thereof is made of Al, and~~

~~such step of forming said Al layer through the sputtering method while heating said circuit board in a temperature range of 100 to 400°C is included.~~

~~A semiconductor device fabrication method for fabricating the semiconductor device of the present invention is such that~~

~~said surface protective film is made of SiN, and~~

~~such step of forming said surface protective film by depositing SiN through the plasma excitation CVD method having an RF power of 300 W or less is included.~~

~~The above semiconductor device of the present invention can show a superior performance that the ferroelectric pair thin film of the ferroelectric capacitor is not deteriorated.~~

~~Moreover, the semiconductor device fabrication method of the present invention can realize a semiconductor device having the above superior performance.~~

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TOTAL 4240660

### SUMMARY OF THE INVENTION

The present invention is made to solve the above conventional problems and its object is to provide a semiconductor device capable of integrating a ferroelectric thin film free from characteristic deterioration and its fabrication method.

A semiconductor device of the present invention comprises a circuit board, a ferroelectric capacitor arrange on the circuit board having a ferroelectric think film and top and bottom electrodes which are formed so as to hold said ferroelectric thin film, an insulating film formed on the circuit board so as to cover said ferroelectric capacitor, a metallic wiring film formed on the insulating film so as to connect with either of the top and bottom electrodes, and a surface protective film formed so as to cover the insulating film and the metallic wiring film, wherein a synthetic stress working in a surface direction of the ferroelectric thin film of said ferroelectric capacitor is an extensional stress.

In another aspect of the present invention, the insulating film, metallic wiring film, and surface protective film provide the surface-directional extensional stress of the ferroelectric thin film of the ferroelectric capacitor.

In a further aspect of the present invention, the metallic wiring film is constituted with two layers which are different kinds of metal.

A semiconductor device fabrication method for fabricating the semiconductor device of the present invention comprises the step of: forming said insulating film on said ferroelectric capacitor by the TEOS-CVD method utilizing TEOS activated by  $O_3$ .

A semiconductor device fabrication method for fabricating the semiconductor device of a further aspect of the present invention is such that the metallic wiring film is constituted with two layers where a bottom layer thereof is made of TiN, and such step of heat-treating of said formed TiN layer

in a temperature range of 200 to 650°C after forming said TiN layer is included.

A semiconductor device fabrication method for fabricating the semiconductor device of another aspect of the present invention is such that said metallic wiring film is constituted with two layers where a top layer thereof is made of Al, and such step of forming said Al layer through the sputtering method while heating said circuit board in a temperature range of 100 to 400°C is included.

A semiconductor device fabrication method for fabricating the semiconductor device of a still further aspect of the present invention is such that said surface protective film is made of SiN, and such step of forming said surface protective film by depositing SiN through the plasma-excitation CVD method having an RF power of 300 W or less is included.

The above semiconductor device of the present invention can show a superior performance that the ferroelectric-pair thin film of the ferroelectric capacitor is not deteriorated.

Moreover, the semiconductor device fabrication method of the present invention can realize a semiconductor device having the above superior performance.

Specification at page 7, line 6:

The semiconductor device of this embodiment is characterized in that the sum of stresses of thin films deposited on the ferroelectric capacitor is an extensional stress. In FIG. 1, arrows show stress directions of thin films. Because the sum of stresses of thin films formed on the ferroelectric capacitor has an extensional direction, an extensional stress or tensile is applied to the ferroelectric capacitor to prevent ferroelectric characteristics from deteriorating.

Specification at page 7, line 15:

Moreover, the semiconductor device of this embodiment is characterized in that every thin film deposited on the ferroelectric capacitor applies an extension-directional stress to the ferroelectric capacitor. Because every thin film deposited on the ferroelectric capacitor has an extension-directional stress, an extensional or tensile (hereinafter “extensional”) stress is applied to the ferroelectric capacitor to prevent ferroelectric characteristic from deteriorating.

CLAIMS:

Claims 1-4, 6, 7, 10, 13 and 15 have been canceled.

5. (Amended) The [A semiconductor device fabrication] method for forming a [fabricating the] semiconductor device according to claim 16 [2; comprising the], in which said step f1) includes [of]:

depositing [forming] said second insulating film [on said ferroelectric capacitor by the] using a TEOS-CVD method utilizing TEOS activated by O<sub>3</sub>.

8. (Amended) The [A semiconductor device fabrication] method for forming a [fabricating the] semiconductor device according to claim 16 [2], [wherein]in which said step f2) includes forming a metal

[said metallic] wiring film by: a) depositing a [is constituted with two layers where a bottom layer thereof is made of] TiN[, and] layer, and b) depositing an upper layer

[such step of heat-treating of said formed TiN layer in a temperature range of 200 to 650°C after forming said TiN layer is included].

said [metallic wiring film is constituted with two layers where a top layer thereof is made of Al, and

such] step of depositing an [forming said] Al layer comprises [through the] sputtering [method] while heating said circuit board in a temperature range of 100 to 400°C [is included].

14. (Amended) The [A semiconductor device fabrication] method for forming a [fabricating the] semiconductor device according to claim 16 [2], wherein

said [surface protective film is made of SiN, and

such] step of forming said surface protective film comprises [by] depositing SiN through [the] a plasma-excitation CVD method having an RF power of 300 W or less [is included].

Claims 16 and 17 have been added.

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PRIOR ART

Fig. 3

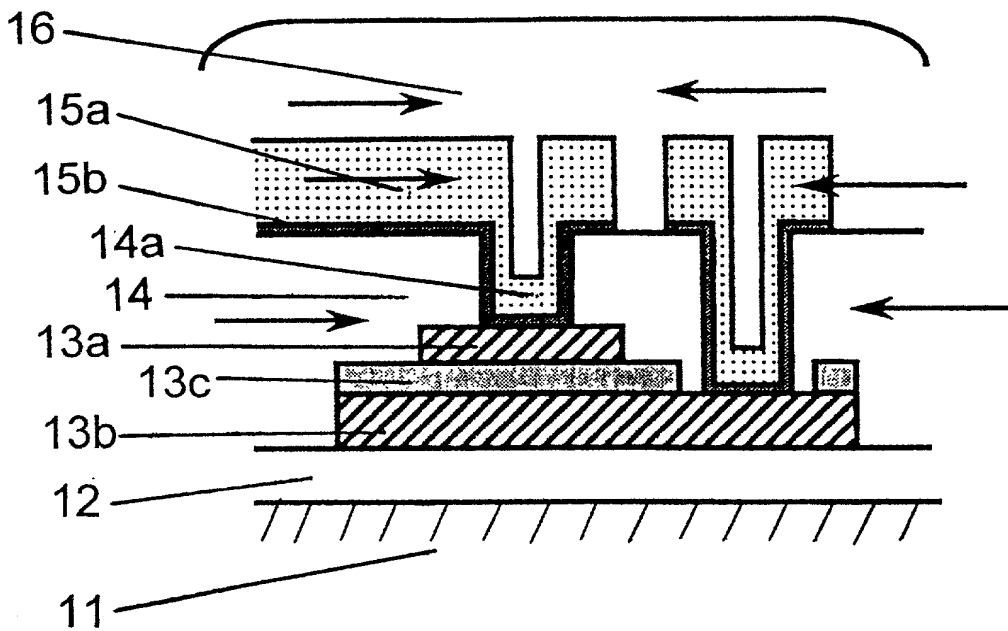


Fig. 4

PRIOR ART

